

Processing of San Simeon Aftershock Data: Results from Portable Seismic Stations Deployed Following the San Simeon Main Shock

Abstract:

Immediately following the M6.5 San Simeon earthquake, December 22, 2003, researchers from the Institute for Crustal Studies (ICS) and the SCEC portable broadband instrument center (PBIC) mobilized instrumentation to record aftershock activity associated with this event. Within the first 24 hours, three stations were deployed in the Paso Robles area, along with one station in Cambria, and one station in Atascadero. Two additional stations were deployed in early January at strong motion stations in San Luis Obispo and Cambria that had recorded the main shock. California State University, Northridge (CSUN) also deployed two stations. The SCEC PBIC stations alone have detected over 2,700 events associated with the Northern California Earthquake Data Center (NCEDC) catalog. In addition to the SCEC PBIC deployment, the US Geological Survey (USGS) deployed six stations closer to the center of aftershock activity. THE SCEC PBIC stations were installed along the perimeter of the aftershock sequence in urban areas while the USGS stations were deployed atop the main sequence of aftershocks in more rural locations. The two deployments complement each other well and together should provide a very useful data set for more accurately determining event hypocenters, crustal structure, and for examining earthquake source properties. The USGS data was transferred to UCSB and has now been integrated with the SCEC/CSUN data into a single data set. The next step is to associate the combined data with the

NCEDC catalog. The number of recorded earthquakes is expected to increase after the association is completed.

The data that I worked with was obtained directly from seismic stations installed by the United States Geological Survey (USGS) and the Southern California Earthquake Center's (SCEC) Portable Broadband Instrument Center (PBIC). The seismic stations were installed in the general area of Paso Robles and San Simeon after a 6.5M earthquake ruptured six miles away from the city of San Simeon, California. A total of seventeen separate seismic stations were installed; eight from the USGS and nine from the SCEC PBIC.

The computers that I used to process the data were UNIX machines and that was something that I had never used. I went through many UNIX tutorials and I had borrowed a UNIX for DUMMIES book from my library. Very often, I referred to my dummies manual. I learned how to *speak* the UNIX language within a few days, which was a big task, according to my mentor, Jamison "Jamie" Steidl. Being able to use the UNIX language allowed me to actually start working with the data.

The data loggers, a component of each seismic station which saves all of the data, store the data in a raw format which could not be used unless processed into other formats. A big part of my internship dealt with processing data into the correct and proper formats. This is much harder than it sounds and is a very tedious process. The computer programs and commands are very picky regarding the format of the data, and there were numerous incompatibilities between the USGS and the SCEC PBIC data. Many problems with compatibility of the data sets occurred and each time, the processing had to be started over with new adjustments and parameters. Another problem was that

my advisor had never used the programs that I had been using to process the data and input into a relational database system, Antelope. So my mentor was learning along the way with me, especially when I ran into problems. We would sit and try to solve the problems and setbacks.

One of the major problems dealing with compatibility issues took weeks to resolve. A command called *dbdetect* needed to be run. The command *dbdetect* would go through all of the waveform data from all seventeen stations and plot out detections according to the many parameters that were assigned. The problem was that the waveform data could not be detected no matter what was tried. If that error was fixed, another error would be given, saying that a *detection table* could not be found. After weeks of trying, my mentor and I still had no idea how to get the command to work.

My mentor, Jamie Steidl, asked one of his colleagues how she went about processing her data and she sent us the procedures. Everything worked out good, including *dbdetect*, and it seemed like there would only be smooth sailing after that. But a crucial command, *dbtrigger*, would not run properly. *Dbtrigger* would go through the integrated data and automatically pick out associated events on multiple stations based on parameters that I had set. Being able to run *dbtrigger* would greatly shorten the time required to pick out each event, as there are at least 4,000 events. Unfortunately, the SCEC PBIC data could not be processed the way Jamie's colleague had told us. Once again, there were compatibility issues that the programs did not like.

What solved the problem was using a combination of procedures and steps. Some steps and commands worked better for the USGS data and other commands worked better for the SCEC PBIC data. I was able to obtain the expected results after using

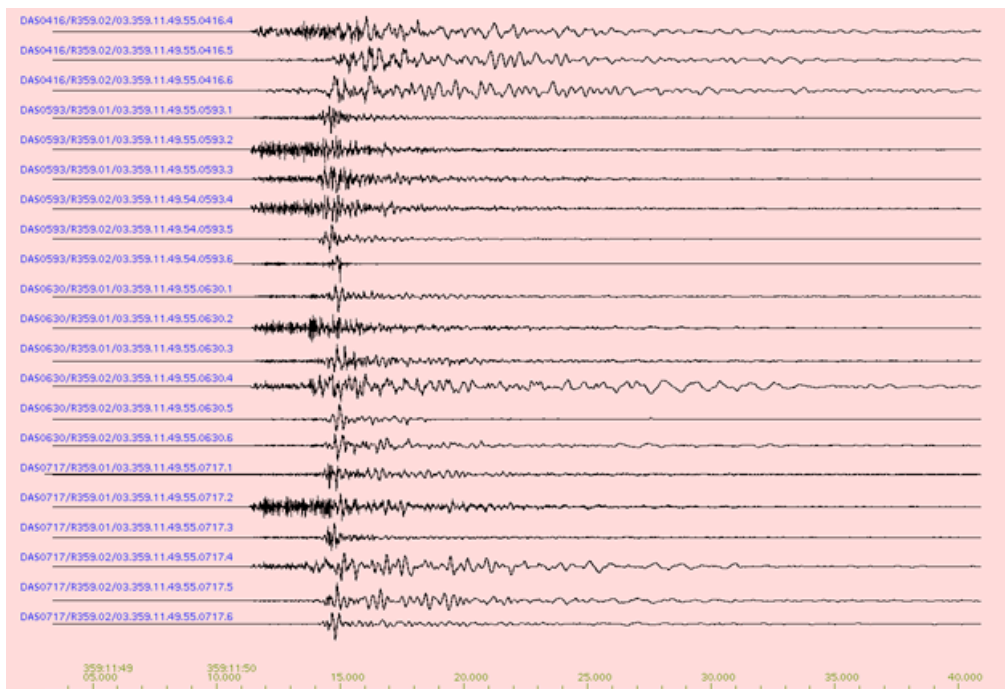
separate processing procedures for each set of data and then integrating them into one data set. After being able to integrate the separate data sets into one data set, the next step of the project could begin.

The ultimate objective of the project is to have a single relational database that contains all of the waveform data along with a large set of events that will be available to researchers, such as tomographers, to use in their research. The main portion of the database that researchers will use is the event arrival times for each aftershock. For this portion of the project, I used the *dbpick* program which is a part of the Antelope software. Using this program, I could scroll through all of the events in the database, looking at specific or all of the stations. I could scroll to any day or time that I wanted as well. A lot of the data obtained from seismic stations are full of background noise, which can trigger as an event, but is not an actual event. This can be prevented somewhat by playing with some of the parameters when running *dbdetect*, which I did. This was a slow process and took hours of trial and error.

Upon scrolling through the events one by one, I had to weed out the false events, which were usually attributed to background noise and sometimes large vehicles. If the detection was an actual event, then I had to determine the arrival times of the primary wave (P-wave) and the secondary wave (S-wave). This had to be done for each station, which had either three or six channels, each recording a different component. The program also allows me to assign an error associated with each pick for every event. This is a very tedious process that requires consistency, precision, and accuracy.

There are approximately 2,700 confirmed events and that is from the data that has not been associated with the NCEDC catalog. The combined data set has more than the

2,700 confirmed events and is very rich in data. I was not able to even come close to finish assigning the P and S waves to each of the events. The seventeen deployed seismic stations were set out for a little over three months and one station for over six months. There were so many recorded events everyday and so many stations, each with three or six channels, that it took me many days of work just to finish one day's worth of aftershock events. I was not able to get through even a week's worth of recorded events. The figure below shows a plot of a particular event that occurred on December 25, 2003, at 11:50 AM. This event occurred three days after the initial main shock. Using the *dbpick* program, I am able to move the stations' orders around, zoom in and out, and do whatever is necessary to properly identify and pick out the P and S waves, as well as assign errors to each pick. The completed project would consist of every single event having their P and S waves picked and errors assigned so that researchers can use the integrated data set.



Sample plot of an event that on Christmas Day that triggered on seven different stations, of which four are shown.